# PIPE MATERIAL REQUIREMENTS

| Type | Size Limits | Design "n" Values | Other Requirements |
|---|---|---|---|
| Reinforced Concrete Pipe (R.C.P.) | 15" to 84" | 0.013 | Use at least Class IV pipe meeting requirements of AASHTO M 170. |
| Horizontal Elliptical Reinforced Concrete Pipe (H.E.R.C.P.) | 23"x 14" to 53"x 34" | 0.013 | Use at least Class IV pipe meeting requirements of AASHTO M 207. |
| Corrugated Steel Pipe, Aluminized Type 2 (C.S.P.) | 15" to 60" | 0.024 | Use at least 14 gage pipe meeting requirements of AASHTO M 36 for Type I pipe. Use only helical corrugations. Aluminum–coated conforming to M 274 |
| Corrugated Aluminum Pipe (CAP) | 15" to 60" | 0.024 | M 196, Type I |
| Corrugated Steel Pipe – Arch, Aluminized Type 2 (C.S.P.A.) | 17"x 13" to 71"x 47" | 0.024 | Use at least 14 gage pipe meeting requirements of AASHTO M 36 for Type II pipe. Use only helical corrugations. Aluminum–coated conforming to M 274 |
| Corrugated Aluminum Pipe–Arch (CAPA) | 17"x 13" to 71"x 47" | 0.024 | M 196, Type II |
| Corrugated Polyethylene Pipe (CPP-S) | 15" to 48" | 0.013 | Use pipe meeting requirements of AASHTO M 294-90. Use only type S (smooth interior) pipe with soil-tight couplings. To be used outside the pavement template only, unless prior approval is obtained from Highway Hydraulics Division. Must use granular backfill around pipe. |
| Non-Asbestos Fiber-Cement Storm Drain Pipe (FCP) | 12" to 48" | 0.013 | C 1450 |
| Polyvinal Chloride Profile Wall Pipe (PPWP) | 18" to 48" | 0.013 | M 304 To be used outside the pavement template only, unless prior approval is obtained from Highway Hydraulics Division. Must use granular backfill around pipe. |
| Steel Spiral Rib Pipe, Aluminized Type 2 (SRP) | 18" to 60" | 0.013 | Use at least 14 gage pipe meeting The requirements of AASHTO M 36 for Type IR pipe. Aluminum–coated conforming to M 274 |
| Steel Spiral Rib Pipe Arch, Aluminized Type 2 (SRPA) | 17"x 13" to 71"x 47" | 0.013 | M 36, Type IIR, 14 ga minimum, Aluminum–coated conforming to M 274 |
| Aluminum Spiral Rib Pipe (ASRP) | 18" to 60" | 0.013 | M 196, Type IR |
| Aluminum Spiral Rib Pipe Arch (ASRPA) | 17"x 13" to 71"x 47" | 0.013 | M 196, Type IIR |
| Structural Steel Plate Pipe (SPP) | 60" to 96" | 0.021 | M 167 |
| Structural Steel Plate Pipe Arch (SPPA) | 60" to 96" diameter equivalent | 0.021 | M 167 |

Height of Cover Limits:

Use applicable charts in the Highway Drainage Manual to determine height of cover limits. For spiral rib pipe, use same height of cover limits as for comparably sized corrugated metal pipe with 2 2/3"x ½" -corrugations. For polyethylene pipe, consult manufacturers literature -however minimum cover shall be 2 feet.

SHA.-61.1-490
IV-3-13-1
9-1-80

# MARYLAND STATE HIGHWAY ADMINISTRATION

## CULVERT ANALYSIS

SHEET ______ OF ______

DATE- ______

DESIGNED BY- ______________ CONTRACT- ______________

CHECKED BY- ______________ TITLE - ______________

### HYDROLOGIC INFORMATION

**SCS METHOD**

AREA - ______ AC.= ______ SM.

RCN. = ______

$t_c$ = ______ MIN. = ______ HRS.

**RATIONAL METHOD**

AREA - ______ AC.

$C_w$ = ______

$t_c$ = ______ MIN.

$i_2$ = ______ "/HR.

$i_{10}$ = ______ "/ HR.

$i_{100}$ = ______ "/ HR.

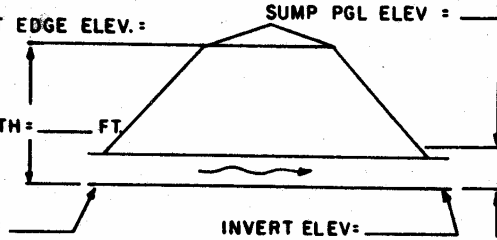
CULVERT DIMENSION(S)- ______ IN. = ______ FT.

CULVERT STATION ______

SUMP STATION ______

SUMP PGL ELEV = ______

SUMP PAVEMENT EDGE ELEV. =



AHW DEPTH = ______ FT.

INVERT ELEV = ______

INVERT ELEV = ______

$S_o$ = ______ %

L = ______ FT.

| CULVERT TYPE & ENTRANCE TYPE | Q C.F.S | HEADWATER COMPUTATION | | | | | | | | | | | | | CONTROLLING HW | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | INLET CONTROL | | OUTLET CONTROL | | | | | | | | | | | | | |
| | | $\frac{HW}{D}$ | HW | $K_e$ | Dc | $\frac{Dc+D}{2}$ | TW | $h_o$ | $S_fL$ | $V_f$ | $V_f^2/2g$ | H | LSo | HW | DEPTH | SURF. ELEV. | |
| | | | | | | | | | | | | | | | | | |
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**FORMULAE:**

**OUTLET CONTROL:**

$HW = ho + H - LSo$

$H = S_fL + (1 + K_e)(\frac{V_f^2}{2g})$

REFERANCE: PAGES 53 TO 54

REMARKS:

SHA-61.1-491 | MARYLAND STATE HIGHWAY ADMINISTRATION | SHEET ______ OF ______
9-1-80 IV-3-13-2 | INLET SPACING | DATE- ____________

DESIGNED BY- ____________ CONTRACT NO. ______

CHECKED BY- ____________ PROJECT ____________ RAINFALL FACTORS ____ ____ ____

DURATION: 0-10 10.1-40 40.1-150

| INLET | AREA | C | CA | BYPASS | TOTAL | $t_c$ | $i_2\, i_f$ | $Q_2$ | INLET | CROSS | CHART | STREET | SPREAD | PICKUP | BYPASS | INLET TO | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NO. | ACRES | | | CA | CA | MIN. | "/hr | CFS | TYPE | SLOPE | NO. | GRADE | FT. | % | CA | NO. | |
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SHA-61.1 - 492
9-1-80 IV-3-13-3

MARYLAND STATE HIGHWAY ADMINISTRATION

SHEET ___ OF ___

## STORM SEWER DESIGN

DESIGNED BY: ____________
CHECKED BY: ____________

CONTRACT ______________________

TITLE ______________________

RAINFALL FACTORS: ____ ____ ____
DURATION: 0-10 10.1-40 40.1-150

| Structure | | Contributing Area | | | | ___ Year Runoff | | | | | Pipe | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | C Area (#) | A Area Acres | Runoff Coef. | Δ CA | ΣA | ΣCA | $t_c$ Time Conc. Min. | $i_{if}$ Rainfall intens. in./hr. | Q cfs | Size in. | Type | n Manning's Coef. | $S_o$ Slope % | L Length Ft. | $V_o$ Vel. ft./sec. | Time in Pipe Min. | Capac. Full cfs | |
| | | | | | | | | | | | | | | | | | | | |
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SHA-61.1-493
1-1-77 IV-3-13-4

MARYLAND STATE HIGHWAY ADMINISTRATION

SHEET __ OF __

HYDRAULIC GRADIENT FOR STORM SEWERS

DATE ________

DESIGNED
CHECKED BY: ______________

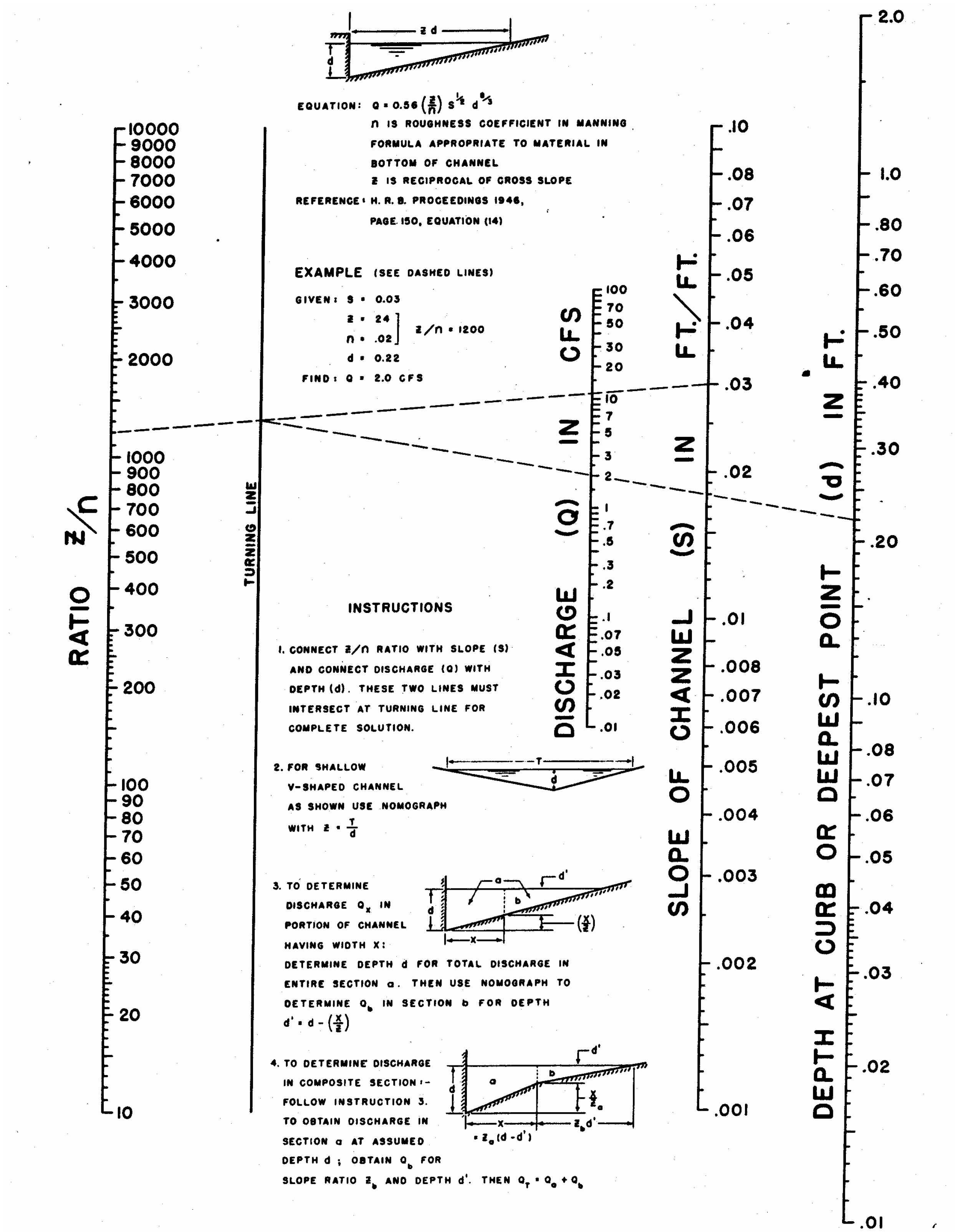
CONTRACT ______________________________

RAINFALL FACTOR __________

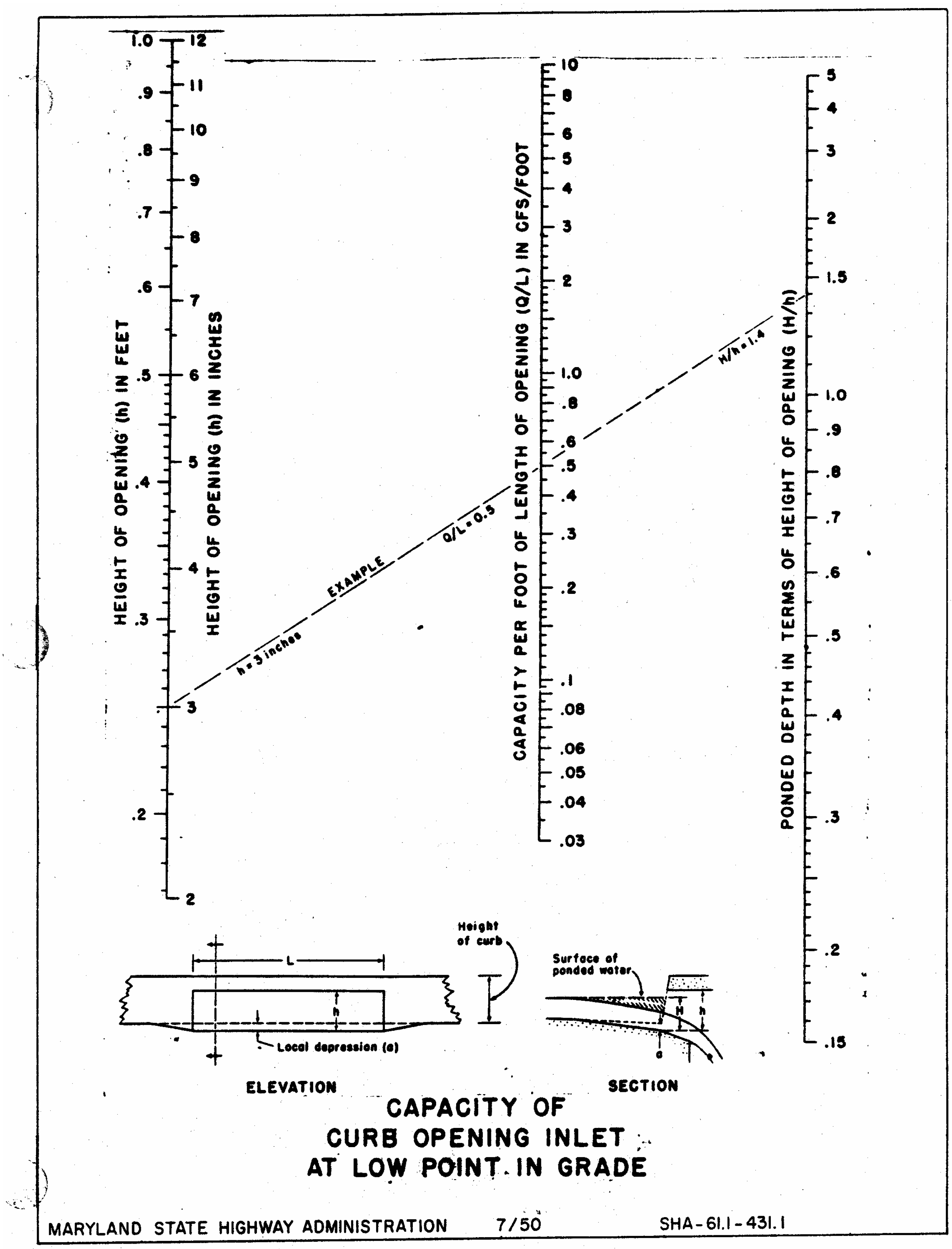
TITLE ______________________________

* FROM FORM SHA-61.1-420

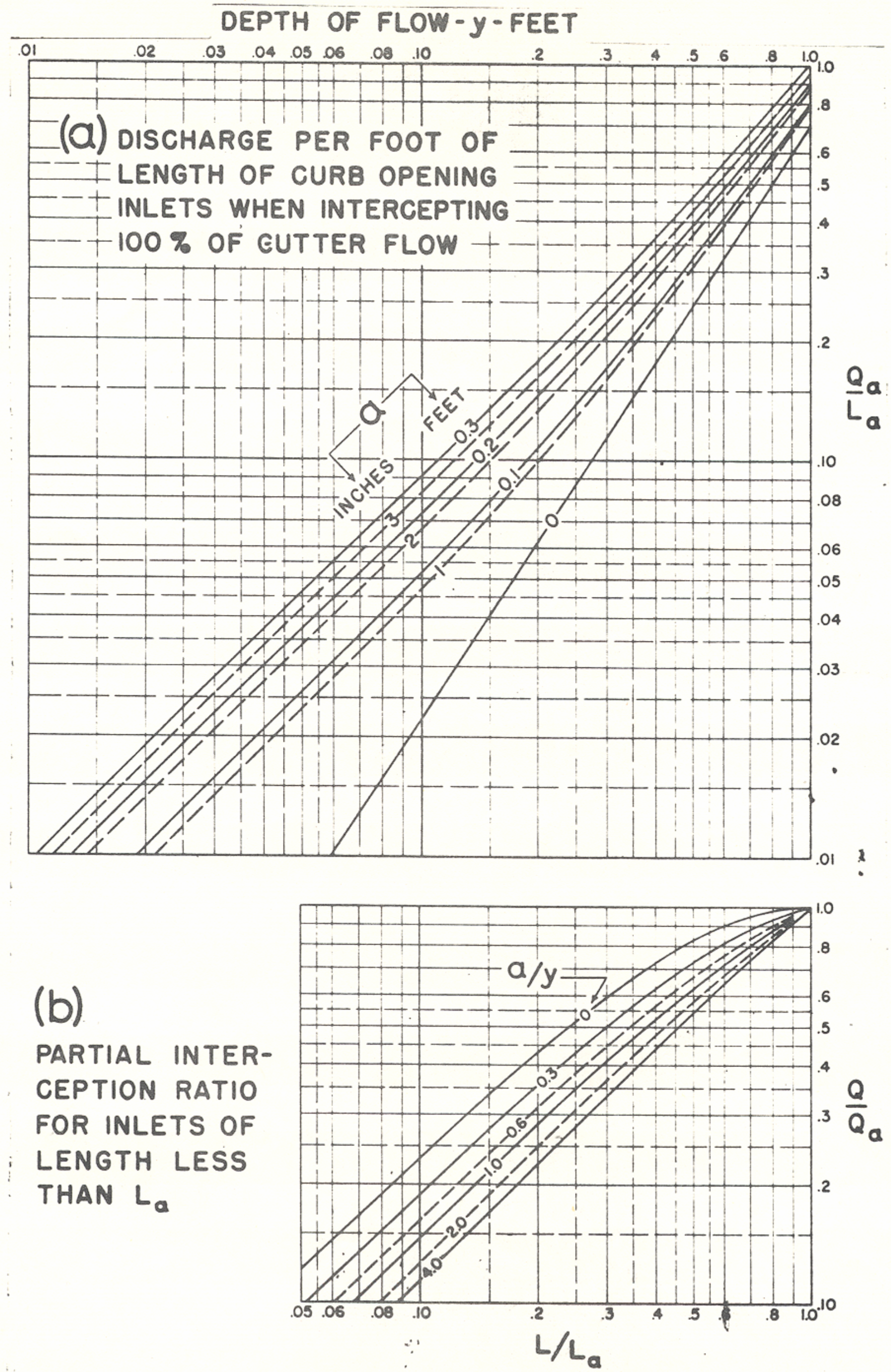
| Structure | | __ Year Runoff | | | | Pipe | | | | | | | | | Hydraulic Gradient | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | ΣCA * | $t_c$ * | i Rainfall intens. in/hr. | Q cfs. | Size In. * | n * Manning's Coef | $S_o$ Slope * % | $S_f$ Slope % | $V_f$ Vel ft./sec | L Length Ft. * | $d_n$ Normal Depth ft | $K_b$ | Desciption of Loss | Elevation |




NOMOGRAPH FOR FLOW IN TRIANGULAR CHANNELS


HEIGHT OF OPENING (h) IN FEET
HEIGHT OF OPENING (h) IN INCHES
CAPACITY PER FOOT OF LENGTH OF OPENING (Q/L) IN CFS/FOOT
PONDED DEPTH IN TERMS OF HEIGHT OF OPENING (H/h)
h = 3 inches
EXAMPLE
Q/L = 0.5
H/h = 1.4
Height of curb
Surface of ponded water
L
h
H
Local depression (a)
ELEVATION
SECTION
CAPACITY OF
CURB OPENING INLET
AT LOW POINT IN GRADE
MARYLAND STATE HIGHWAY ADMINISTRATION
7/50
SHA-61.1-431.1

IV-3-7-2




## CAPACITY OF CURB OPENING INLETS ON CONTINUOUS GRADE

IV-3-7-1

MARYLAND STATE HIGHWAY ADMINISTRATION 7/50 SHA-61.1-431.0

Instructions for Use of Figure 431.0 (a) and (b)
"Capacity of Curb Opening Inlets on Continuous Grade"

Figure 431.0 applies to curb or side opening inlets on continuous grades.

The capacity of the inlet depends upon the length of opening and the depth of flow at the upper end of the opening. This depth in turn depends upon the amount of depression of the flow line at the inlet and the cross slope, longitudinal slope, and the roughness of the gutter.

To use figure 431.0 (a) and (b) for curb opening inlets the following information must be know:

1. Length (L) of the inlet opening.

2. Depth (a) of local flow line depression, if any, at the inlet. (See Page I-4-A-1) of the Highway Drainage Manual

3. Design discharge (Qa) in the gutter or information as to drainage area, rainfall intensity, and runoff coefficients from which a design discharge can be estimated. Any carry-over from a previous inlet must be included.

4. Depth of flow in normal gutter for the particular longitudinal and cross slopes at the inlet in question. This may be determined from the following figure: 430.1.

Procedure

1. Enter Figure 431.0 (a) with depth of flow, *y* from Figure 430.1, local depression, a, and determine $Q_aL_a$ , the interception per foot of inlet opening if the inlet were intercepting 100% of the flow.

2. Determine length of inlet $L_a$ required to intercept 100% of the flow. $L_a$ = total flow $Q_a$ divided by the factor $Q_a/L_a$.

3. Compute ratio $L/ L_a$ where L= actual length of inlet in question.

4. Enter Figure 431.0 (b) with $L/L_a$ and the ratio a/y and determine ratio $Q/O_a$, the proportion of the total flow intercepted by the inlet in question.

5. Flow intercepted, Q, is this ratio $Q/Q_a$ times the total flow $Q_a$.

6. Flow carried over to next inlet is $Q_a – Q$.

Rev. 1983 **SNA** 61.1 **431.A**